

Resolution: - BOS/ 18.12.21

Bharatiya Vidya Bhavan's

**M. M. College of Arts, N.M. Institute of Science, H.R.J.
College of Commerce. (Bhavan's College) Autonomous**

(Affiliated to University of Mumbai)



Syllabus for: S.Y.B.Sc.(Statistics)

Program: B.Sc.

Program Code: BH. BSc.

Course Code: BH. USST

Choice Based Credit System (CBCS)

with effect from academic year 2022-23



PROGRAM OUTCOMES

PO	A learner completing bachelor's degree in science program will be able to acquire the following:
PO-1	Disciplinary Knowledge: Capable of demonstrating comprehensive knowledge and understanding of one or more other disciplines that form a part of an undergraduate programme of study. This programme helps students in building a solid foundation for further higher studies and research.
PO-2	Critical Thinking & Competency in Skills: Take informed actions after identifying the assumptions that frame our thinking and actions. Critically evaluate practices, policies, and theories by following scientific approach to knowledge development. Obtain proficiency in analytical reasoning, critical understanding, analysis, and synthesis in order to solve theoretical and practical problems. This can orient students towards applications of their subject in other disciplines and, can also be utilized in modelling and solving real life problems.
PO-3	Communication Skills: Ability to express thoughts and ideas effectively in writing and orally; communicate with others using appropriate media; confidently share one's views and express herself/ himself; demonstrate the ability to listen carefully; and present complex information in a clear and concise manner to different groups.
PO4	Social Interaction: Ability to work effectively and respectfully with diverse teams; facilitate cooperative or coordinated effort on the part of a group and act together as a group or a team in the interests of a common cause. Elicit views of others, mediate disagreements and help reach conclusions in group settings.
PO5	Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.
PO6	Interdisciplinary and Research Skills: A sense of inquiry and capability for asking relevant/ appropriate questions, Ability to recognize cause-and- effect relationships, define problems, formulate hypotheses, interpret and draw conclusions from data, ability to plan, execute and report the results of an experiment or investigation which will enable them to apply one's learning to real life situations.
PO7	Proficiency in Employments: This programme will help students to enhance their employability for Government jobs, related to science, data analysis jobs, and jobs in various other public and private enterprises.

PROGRAM SPECIFIC OUTCOMES

PSO	DESCRIPTION
	A learner completing bachelor's degree in B.Sc. program in the subject of Statistics will be able to
PSO-1	use elementary tools using electronic spreadsheets in Descriptive Statistics and Statistical Methods, as the learner offers for the first time in his educational career, the subject Statistics as an Independent Subject.
PSO-2	have sound mathematical base for various Statistical Methods such as Standard Discrete & Continuous Probability Distributions, Exact Sampling Distributions, Sampling Techniques, ANOVA Techniques and further exploring applied nature of subject by receiving exposure to some optimization techniques.
PSO-3	Gain comfortable level of confidence in using statistical software.
PSO-4	have rigorous mathematical basis to various inferential statistical methods such as Estimation, Testing of Hypotheses, Distribution Theory & Stochastic Processes, Biostatistics and Operations Research techniques.
PSO-5	inculcate sound logical thinking due to exposure to advanced topics in Probability.
PSO-6	make learner industry ready due to use R software/Python programming in theory papers/skill enhancement papers.

BSc (Statistics): Rationale behind Revision of Syllabus

To create sound theoretical (mathematical) base for various Statistical Methods and to learn their applications using Open Source/Licensed Statistical Software/packages by teaching the subject right from scratch to major techniques in Inferential Statistics which are useful in exploratory data analysis.

In view of rationale,

- First year Syllabus gives emphasis on learning of elementary topics in Descriptive Statistics and Statistical Methods, as the learner offers for the first time in his educational career, the subject Statistics as an **Independent Subject**. Data analysis using spreadsheets in one component in practicals. Syllabus offered by University of Mumbai has been reorganized under Autonomy.
- Second year syllabus would expose learner to sound mathematical base for various Statistical Methods such as Standard Discrete & Continuous Probability Distributions, Exact Sampling Distributions, Sampling Techniques, ANOVA Techniques and further exploring applied nature of subject by teaching them some optimization techniques. Data analysis using R software would be one component in practicals.
- Third year syllabus would extend more rigorous mathematical basis to various inferential statistical methods such as Estimation, Testing of Hypotheses, Distribution Theory & Stochastic Processes and Operations Research techniques. Syllabus would also give exposure to advanced topics in Probability which inculcates sound logical thinking in the learners. Learner shall also be exposed to field of Actuarial Science by teaching them basics in field of demography & Insurance. R software/Python programming would find scope in theory papers/skill enhancement papers apart from practicals to make learner industry ready.

PROGRAM OUTLINE FOR BSc

Sem ester	Core course 14 CREDIT(T+P) =2+1 /COURSE	Ability enhancement course CREDIT 2	Skill enhancement course CREDIT 2	Discipline specific elective* CREDIT 3	Generic elective CREDIT04	TOTAL CREDIT S
I	C1: Paper 101 of 3 courses selected	English Communication / Environmental Sc (FC)				20
	C2: Paper 102 of 3 courses selected					
II	C3: Paper 201 of 3 courses selected	English Communication / Environmental SC (FC)				20
	C4: Paper 202 of 3 courses selected					
III	C5: Paper 301 of 2 courses selected		(FC)		(SWAYAM/ Coursera) Optional for ECC	20
	C6: Paper 302 of 2 courses selected					
	C7: Paper 303 of 2 courses selected					
IV	C8: Paper 401 of 2 courses selected		SEC2 (FC)		GE4 (SWAYAM/ Coursera) Optional for ECC	20
	C9: Paper 402 of 2 courses selected					
	C10: Paper 403 of 2 courses selected					
V	C11: Paper 501 of 1 course selected 3 Credits		Practicals based on 2 papers(C11 &12) - 2 Credits	Paper 503 of 1 course selected - 3 Credits	Applied component T+ P (3+1=4 credits)	20
	C12: Paper 502 of 1 course selected 3 Credits		Practicals based on 2 DSE papers- 2 Credits	Paper 504 of 1 course selected - 3 Credits		
VI	C13: Paper 601 of 1 course selected 3 Credits		Practicals based on 2 papers(C13 &14) - 2 Credits	Paper 603 of 1 course selected - 3 Credits	Applied component T+P (3+1=4 credits/EC	20

	C14: Paper 602 of 1 course selected 3 Credits		Practicals based on 2 DSE papers- 2 Credits	Paper 604 of 1 course selected - 3 Credits		
	TOTAL CREDITS					120

Note-

- 1. The final year B.Sc. students will have the options under DSE (Discipline specific Elective) to drop of one the core paper and do dissertations under the guidance of the departmental faculty/ Any research institute of national importance for both semester V & VI.**
- 2. CBCS system will allow the students from science streams in their final year to study the applied component of any of the science subjects available in the college (E.g.- Final year Botany student can have the choice to select any one of the Applied components available with Zoology, Microbiology, Chemistry, Statistics, Physics, Mathematics, etc.).**

Students in semester- III & IV will have the option for selecting the Generic elective (GE) courses prescribed by Swayam/ Coursera/ etc. The students will be evaluated by conducting examinations at college level. The students will also have the options to get certificate from SYAWAM by qualifying their proctored examination.



PROGRAM OUTLINE

YEAR	SEMESTER	COURSE TYPE	COURSE CODE	COURSE TITLE	CREDITS
FYBSc	I	CoreCourse	BH. USST101	Descriptive Statistics I	02
FYBSc	I	CoreCourse	BH. USST102	Statistical Methods II	02
FYBSc	I	CoreCourse	BH. USSTP01	Practical Based on BH. USST101 & BH. USST102	02
FYBSc	II	CoreCourse	BH. USST201	Descriptive Statistics I	02
FYBSc	II	CoreCourse	BH. USST202	Statistical Methods II	02
FYBSc	II	CoreCourse	BH. USSTP02	Practical Based on BH. USST201 & BH. USST202	02
SYBSc	III	CoreCourse	BH. USST301	Probability Distributions	02
SYBSc	III	CoreCourse	BH. USST302	Theory of Sampling	02
SYBSc	III	CoreCourse	BH. USST303	Operations Research I	02
SYBSc	III	CoreCourse	BH. USSTP03	Practical Based on BH. USST301, BH. USST302 & BH. USST303	03
SYBSc	IV	CoreCourse	BH. USST401	Probability & Sampling Distributions	02
SYBSc	IV	CoreCourse	BH. USST402	Analysis of Variance & Designs of Experiments	02
SYBSc	IV	CoreCourse	BH. USST403	Operations Research II	02
SYBSc	IV	CoreCourse	BH. USSTP04	Practical Based on BH. USST401, BH. USST402 & BH. USST403	03
TYBSc	V	CoreCourse	BH. USST501	Probability and distribution theory	03
TYBSc	V	CoreCourse	BH. USST502	Theory of Estimation	03
TYBSc	V	Discipline specific elective	BH. USST503	Biostatistics	03
TYBSc	V	Discipline specific elective	BH. USST504	Regression Analysis using R Software	03
TYBSc	V	Skill enhancement course	BH. USSTP05	Practical Based on BH. USST501 & BH. USST502	02
TYBSc	V	Skill enhancement course	BH. USSTP06	Practical Based on BH. USST503 & BH. USST504	02

TYBSc	V	Generic elective	BH.USACOR501	Elements Of Operations Research I	02
TYBSc	V	Generic elective	BH. USACOR5P1	Practical Based on BH. USACOR501	02
TYBSc	VI	CoreCourse	BH. USST601	Distribution Theory and Stochastic Processes	03
TYBSc	VI	CoreCourse	BH. USST602	Testing of Hypothesis	03
TYBSc	VI	Discipline specific elective	BH. USST603	Operations Research Techniques	03
TYBSc	VI	Discipline specific elective	BH. USST604	Elements Of Actuarial Science	03
TYBSc	VI	Skill enhancement course	BH. USSTP07	Practical Based on BH USST601 & BH. USST602	02
TYBSc	VI	Skill enhancement course	BH. USSTP08	Practical Based on BH USST603 & BH. USST604	02
TYBSc	VI	Generic elective	BH. USACOR601	Elements Of Operations Research II	02
TYBSc	VI	Generic elective	BH. USACOR6P1	Practical Based on BH USACOR601	02

DETAILED SYLLABUS – SEMESTER III & IV

PREAMBLE

BSc (Statistics) Program would create sound theoretical (mathematical) base for various Statistical Methods and to learn their applications using Open Source/Licensed Statistical Software/packages by teaching the subject right from scratch to major techniques in Inferential Statistics which are useful in exploratory data analysis.

Programme: B.Sc.				Semester: III	
Course: Statistics Paper I (PROBABILITY DISTRIBUTIONS)				Course Code: BH. USST301	
Teaching Scheme				Evaluation Scheme (Theory)	
Lecture (Periods per week)	Practical (Periods per week per batch)	Tutorial (Periods per week per batch)	Credits (Theory +Practical)	Continuous Internal Assessment (CIA)	End Semester Examination (ESE)
3	3	--	2+1	(Marks - 40)	(Marks: 60)
Pre-requisites: Basic Properties of Probability, Types of Random Variables and Moments					
Course Objectives:					
1) To understand the patterns in the data of large populations. 2) To obtain the central location and dispersion of the data. 3) To know the relationship between various distributions.					
Course Outcomes:					
1. Learner will be able to find central location and dispersion of the data 2. Learner will be able to identify situations where different discrete and continuous probability models can be applied. 3. Learner will be able to know the relationship between various distributions					
Detailed Syllabus: (per session plan)					
Unit	Description				Periods
1	Moment generating function (MGF): Definition, properties of MGF i) MGF of $aX + b$ ii) MGF of sum of two independent r.v.s. along with the generalization iii) Uniqueness property (only statement). raw moments from MGF. Cumulant Generating Function (CGF): Definition, cumulants from CGF, properties of CGF: i) Effect of shift of origin and scale ii) Additive property of cumulants iii) relationship between cumulants and moments up to order four. Examples of obtaining raw moments and central moments up to order four using M.G.F. and C.G.F. for continuous and discrete distributions. Characteristic Function: Definition and properties. Degenerate distribution (One point distribution) Definition, Mean, Variance. Discrete Uniform distribution: Definition, mean, variance, coefficient of skewness.				15

	<p>Bernoulli distribution: Definition, MGF, Mean, Variance, coefficient of skewness.</p> <p>Binomial distribution: Definition, MGF, Mean, Variance, CGF, Measures of skewness and Kurtosis, Mode, Additive property, Distribution of $n-X$. Recurrence relation for moments, Relationship between Bernoulli and Binomial using M.G.F.</p>	
2	<p>Poisson distribution: Definition, MGF, Mean, Variance, CGF, Measures of skewness and Kurtosis, Mode, Additive property. Recurrence relation for moments, Conditional distribution of X given $X+Y$ where X and Y are two independent Poisson variables, Poisson distribution as limiting distribution of Binomial.</p> <p>Truncated distributions: Definition, Truncated Binomial and Truncated Poisson Distribution (truncated at 0): Probability Mass Function, mean and variance.</p> <p>Hyper geometric distribution: Definition, Mean, Variance, Limiting distribution of Hyper geometric distribution. Conditional distribution of X given $X+Y$ where X and Y are two independent Binomial variables.</p> <p>Rectangular or Continuous Uniform distribution: Definition, M.G.F., Mean, variance, median, measure of skewness.</p> <p>Triangular distribution: Definition, M.G.F. Mean.</p> <p>Exponential Distribution: Definition, M.G.F., C.G.F., moments (up to order four) using M.G.F and C.G.F, Measures of Skewness and Kurtosis, Median and Quartiles and Percentiles, Forgetfulness Property.</p>	15
3	<p>Two dimensional Discrete random variables: Joint Probability mass function and its properties. Distribution Function of (X, Y) and its properties, Definition of raw and central moments, covariance, correlation coefficient, Independence and correlation between two variables. Marginal and conditional probability distributions. Conditional expectation, conditional variance.</p> <p>Continuous bivariate random variables: Joint Probability density function and its properties. Distribution function of (X, Y) and its properties. Marginal and conditional probability distributions. Conditional expectation, conditional variance. Regression Function.</p> <p>Transformation of random Variable (Univariate and Bivariate): Using Distribution Function and Jacobian transformation.</p>	15
	Total	45

Reference Books:

1. Feller W: An introduction to probability theory and its applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R V. & Craig Allen T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt. Ltd.

3. Mood A. M., Graybill F. A., Boes D. C.: Introduction to the theory of statistics, Third edition, McGraw- Hill Series.
4. Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition, McMillan Publishing Company.
5. Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
6. Biswas S.: Topics in Statistical Methodology, First edition, Wiley Eastern Ltd.
7. Kapur J. N. & Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.
8. Chandra T.K. & Chatterjee D.: A First Course in Probability, Second Edition, Narosa Publishing House.
9. V K Rohatgi: An Introduction to probability and Mathematical Statistics.

List of Topics for the practicals:

Topic of the Practical	No. of Practicals
MGF, CGF And Characteristic Function	1
Discrete uniform and Binomial distribution	1
Poisson and Hypergeometric distribution	1
Truncated Binomial and Poisson Distribution Distribution	1
Rectangular and Exponential distribution	1
Bivariate Discrete Distributions	1
Bivariate Continuous Distributions	1
Transformation Of Random Variables	1
Practical using R software	2

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for laboratory work and journal (40+10 =50).

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

Programme: B.Sc.				Semester: III	
Course: Statistics Paper II (THEORY OF SAMPLING)				Course Code: BH. USST302	
Teaching Scheme				Evaluation Scheme (Theory)	
Lecture (Periods per week)	Practical (Periods per week per batch)	Tutorial (Periods per week per batch)	Credits (Theory +Practical)	Continuous Internal Assessment (CIA)	End Semester Examination (ESE)
3	3	--	2+1	(Marks - 40)	(Marks: 60)
Pre-requisites: Concept of Population and sample, Basics of Expectation					
Course Objectives:					
<ol style="list-style-type: none"> 1. To learn concept of Simple Random Sampling, 2. To study need and method of Stratified sampling, 3. To understand various sampling techniques and their applications. 					
Course Outcomes:					
<ol style="list-style-type: none"> 1. Learner will be able to solve examples on estimation of parameters using sampling methods. 2. Learner will be able to identify situations where various sampling techniques can be applied. 					
Detailed Syllabus: (per session plan)					
Unit	Description				Periods
1	<p><u>Concepts:</u> Population, Population unit, Sample, Sample unit, Parameter, Statistic, Estimator, Bias, Unbiasedness, Mean square error & Standard error. Census survey, Sample Survey. Steps in conducting a sample survey with examples on designing appropriate Questionnaire. Concepts of Sampling and Non-sampling errors. NSSO, CSO and their functions. Concepts and methods of Probability and Non-Probability sampling.</p> <p><u>Simple Random Sampling:</u> (SRS). Definition, Sampling with & without replacement (WR/WOR). Lottery method & use of Random numbers to select Simple random sample. Estimation of population mean & total. Expectation & Variance of the estimators, Unbiased estimator of variance of these estimators.</p>				15

	(WR/WOR). Estimation of population proportion. Expectation & Variance of the estimators, Unbiased estimator of variance of these estimators. (WR/WOR). Estimation of Sample size based on a desired accuracy in case of SRS for variables & attributes. (WR/WOR).	
2	<u>Stratified Sampling:</u> Need for Stratification of population with suitable examples. Definition of Stratified Sample. Advantages of stratified Sampling. Estimation of population mean & total in case of Stratified Random Sampling (WOR within each stratum). Expectation & Variance of the unbiased estimators, Unbiased estimators of variances of these estimators. Proportional allocation, Optimum allocation with and without varying costs. Comparison of Simple Random Sampling, Stratified Random Sampling using Proportional allocation & Neyman allocation.	15
3	<u>a. Introduction to other sampling methods:</u> Linear Systematic sampling, Circular Systematic Sampling, Cluster sampling & Two-Stage sampling with suitable illustrations. <u>b. Ratio & Regression Estimation assuming SRSWOR:</u> Ratio Estimators for population Ratio, Mean & Total. Expectation & MSE of the Estimators. Estimators of MSE. Uses of Ratio Estimator. Regression Estimators for population Mean & Total. Expectation & Variance of the Estimators assuming known value of regression coefficient 'b'. Estimation of 'b'. Resulting variance of the estimators. Uses of regression Estimator. Comparison of Ratio, Regression & mean per Unit estimators.	15
	Total	45

Reference Books:

1. Sampling Techniques: W.G. Cochran; 3rd Edition; Wiley (1978)
2. Sampling Theory and methods: M.N. Murthy; Statistical Publishing Society. (1967)
3. Sampling Theory: Des Raj; McGraw Hill Series in Probability and Statistics. (1968).
4. Sampling Theory of Surveys with Applications: P.V. Sukhatme and B.V. Sukhatme; 3rd Edition; Iowa State University Press (1984).
5. Fundamentals of Applied Statistics: S. C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand and Sons (2001).
6. Theory and Analysis of Sample Survey Designs: Daroga Singh, F.S. Chaudhary, Wiley Eastern Ltd. (1986).
7. Sampling Theory and Methods: S. Sampath, Second Edition (2005), Narosa.
8. Theory and Methods of Survey Sampling: Parimal Mukhopadhyay, (1998), Prentice Hall of India Pvt. Ltd.

List of Topics for the practicals:

Topic of the Practical	No. of Practicals
Designing of Questionnaire	1
Simple Random Sampling for Variables	1
Simple Random Sampling for Attributes and Estimation of Sample Size	1
Stratified Random Sampling	2
Ratio Estimation	1
Regression Estimation	1
Use of R-Software	3

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for laboratory work and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

Programme: B. Sc.				Semester: III	
Course: Statistics Paper III (OPERATIONS RESEARCH I)				Course Code: BH. USST303	
Teaching Scheme				Evaluation Scheme (Theory)	
Lecture (Periods per week)	Practical (Periods per week per batch)	Tutorial (Periods per week per batch)	Credits (Theory + Practical)	Continuous Internal Assessment (CIA)	End Semester Examination (ESE)
3	3	--	2+1	(Marks - 40)	(Marks: 60)
Pre-requisites: NIL					
Course Objectives: 1. Introduction to Applied Statistics 2. To learn the concept behind the techniques of Applied Statistics 3. To present theory, application and algorithm relevant to solving linear programming problem, transportation problem and assignment problem 4. Introduction to R Software 5. To understand application of R Software in various areas of Statistics					
Course Outcomes: 1. After completion of course students will be able to utilize Applied Statistics techniques in practical situations. Solve the practical situational problems using various algorithm taught during the course. 2. After completion of course students will be familiar with R Software.					
Detailed Syllabus: (per session plan)					
Unit	Description				Periods
1	<u>Linear Programming Problem (L.P.P.):</u> Mathematical Formulation: Maximization & Minimization. Concepts of Solution, Feasible Solution, Basic Feasible Solution, Optimal solution. Graphical Solution for problems with two variables. Simplex method of solving problems with two or more variables. Big M method. Concept of Duality. Its use in solving L.P.P. Relationship between optimum solutions to Primal and Dual. Economic interpretation of Dual.				15

2	<u>Transportation Problem:</u> Concept, Mathematical Formulation. Concepts of Solution, Feasible Solution. Initial Basic Feasible Solution by North-West Corner Rule, Matrix Minima Method, Vogel's Approximation Method. Optimal Solution by MODI Method. Optimality test, Improvement procedure. Variants in Transportation Problem: Unbalanced, Maximization type.	15
3	<u>Assignment Problem:</u> Concept. Mathematical Formulation. Solution by: Complete Enumeration Method and Hungarian method. Variants in Assignment Problem: Unbalanced, Maximization type. Travelling Salesman Problem. <u>Sequencing:</u> Processing n Jobs through 2 and 3 Machines & 2 Jobs through m Machines	15
	Total	45

Reference Books:

1. Operations Research: Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons.
2. Schaum Series book in O.R. Richard Broson. 2nd edition Tata McGraw Hill Publishing Company Ltd.
3. Mathematical Models in Operations Research: J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.
4. Principles of Operations Research with Applications to Management Decisions: Harvey M. Wagner, 2nd Edition, Prentice Hall of India Ltd.
5. Operations Research: S.D. Sharma. 11th edition, Kedar Nath Ram Nath & Company.
6. Operations Research: H. A. Taha. 6th edition, Prentice Hall of India.
7. Quantitative Techniques for Managerial Decisions: J.K. Sharma, (2001), MacMillan India Ltd.
8. S.G. Purohit, S.D. Gore, S.R. Deshmukh, Statistics using R Narosa Publishing
9. Maria.L. Rizzo (2007), Statistical Computing with R - (Chapman& Hall/CRC)

List of Topics for the practical:

Topic of the Practical	No. of Practical
LPP	3
Transportation Problem	2
Assignment Problem & Travelling Salesman Problem	1
Sequencing	1
Use of R software in Operations Research Problems.	3

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for laboratory work and journal (40+10 =50): Course code BH. USSTP03

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

Programme: B.Sc.				Semester: IV	
Course: Statistics Paper I (PROBABILITY AND SAMPLING DISTRIBUTIONS)				Course Code: BH. USST401	
Teaching Scheme				Evaluation Scheme (Theory)	
Lecture (Periods per week)	Practical (Periods per week per batch)	Tutorial (Periods per week per batch)	Credits (Theory +Practical)	Continuous Internal Assessment (CIA)	End Semester Examination (ESE)
3	3	--	2+1	(Marks - 40)	(Marks: 60)
Pre-requisites: Basic Properties of Probability, Types of Random Variables and Moments.					
Course Objectives:					
1)To understand the patterns in the data of large populations. 2) To obtain the central location and dispersion of the data. 3) To know the relationship between various distributions.					
Course Outcomes:					
1. Learner will be able to identify situations where exact sampling distributions can be applied. 2. Learner will be able to identify situations where different discrete and continuous probability models can be applied. 3.Learner will be able to know the relationship between various distributions.					
Detailed Syllabus: (per session plan)					
Unit	Description				Periods

1	<p>Geometric Distribution: Definition, M.G.F., Mean and Variance, C.G.F., Coefficients of skewness and Kurtosis. Lack of Memory property. Conditional distribution of X given X+Y where X and Y are two i.i.d. Geometric variables, Additive property.</p> <p>Negative Binomial Distribution: Definition, M.G.F., Mean and Variance, C.G.F., Recurrence relation for central moments, Recurrence relation for probabilities, Limiting distribution of Negative Binomial distribution.</p> <p>Gamma (with Scale and shape parameter): Definition, Expression for r^{th} raw moment, M.G.F., C.G.F. moments (up to order four) using M.G.F. and C.G.F, Measures of Skewness and Kurtosis, Mode, Additive property, Distribution of i) $\frac{X}{Y}$ ii) $\frac{X}{X+Y}$ where X and Y are independent Gamma variables.</p> <p>Beta Distribution Type I: Definition, Expression for r^{th} raw moment, Mean, variance, distribution of 1- X.</p> <p>Beta Distribution Type II: Definition, Expression for r^{th} raw moment, Mean, variance, distribution of i) $\frac{1}{1+X}$, ii) $\frac{X}{1+X}$.</p>	15
2	<p>Cauchy (with location and scale parameter): Definition, Properties with proof.</p> <p>Normal distribution: Definition, M.G.F., C.G.F., Mean, variance, skewness & kurtosis, Median, Mode, Mean absolute deviation. Properties, odd and even ordered central moments, Distribution of linear function of independent Normal variables. (i) aX, (ii). $X+b$, (iii) $\sum a_i x_i$, <i>Fitting</i> of the Distribution. Central Limit theorem for i.i.d. random variables.</p> <p>Log Normal Distribution: Definition, mean, variance, Distribution of product of n log normal random variables.</p>	15
3	<p>Chi-Square Distribution: Derivation of p.d.f., Concept of degrees of freedom, M.G.F., C.G.F., Mean, variance, Measures of skewness and Kurtosis, Mode, Additive property, Distribution of i) $\frac{X}{Y}$ ii) $\frac{X}{X+Y}$ where X and Y are two independent Chi-square variables. Distribution of the sum of squares of independent Standard Normal variables. Sampling distributions of sample mean and sample variance and their independence for a sample drawn from Normal distribution.</p> <p>Applications of Chi-Square: Test of significance for specified value of variance of a Normal population, Test for goodness of fit, Test for independence of attributes. Derivation of Confidence interval for the</p>	15

	<p>variance of a normal population when (i) mean is known, (ii) mean is unknown.</p> <p>t-distribution: Derivation of p.d.f., Expression for r^{th} ordered raw moment, odd and even ordered central moments, Mean, Median, mode, Mean Deviation, asymptotic property. Fisher's t variate. Student's t variate.</p> <p>Applications of t: Test of significance for specified value of mean of Normal population. Test procedure of test of significance for difference between means of (i) two independent Normal populations with equal variances, (ii) paired samples (Paired t test). Derivation of Confidence intervals for (i) Mean of Normal population, (ii) difference between means of two independent Normal populations having the same variance.</p> <p>Snedecor's F-distribution: Derivation of p.d.f., Expression for r^{th} raw moment, Mean, variance, Mode, Distribution of Reciprocal of F variable.</p> <p>Applications of F: Test procedure for testing equality of variances of two independent Normal populations where (i) Mean is known (ii) Mean is unknown. Derivation of confidence interval for ratio of variances of two independent Normal populations.</p>	
	Total	45

Reference Books:

1. Introduction to the theory of statistics: A M Mood, F.A. Graybill, D C Boyes; Third Edition. McGraw-Hill Book Company.
2. Introduction to Mathematical Statistics: R.V. Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
3. Probability and Statistical Inference: R.V. Hogg, E. A. Tannis, Third Edition; Collier McMillan Publishers.
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
5. Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
6. Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
7. Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.

List of Topics for the practicals:

Topic of the Practical	No. of Practicals
Geometric And Negative Binomial Distribution	1
Gamma and Beta Distribution	2
Univariate Normal distribution	1
Log normal distribution and Cauchy distribution	1

Applications of central limit theorem	1	
Application of χ^2 , t and F distribution	2	
Practical using R Software	2	
Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for laboratory work and journal (40+10 =50).		
Details of Continuous Internal Assessment (CIA) For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).		
Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.		

Programme: B.Sc.				Semester: IV	
Course: Statistics Paper II (ANALYSIS OF VARIANCE & DESIGN OF EXPERIMENTS)				Course Code: BH. USST402	
Teaching Scheme				Evaluation Scheme (Theory)	
Lecture (Periods per week)	Practical (Periods per week per batch)	Tutorial (Periods per week per batch)	Credits (Theory +Practical)	Continuous Internal Assessment (CIA)	End Semester Examination (ESE)
3	3	--	2+1	(Marks :40)	(Marks: 60)
Pre-requisites: Basics of sampling					
Course Objectives:					
<ol style="list-style-type: none"> 1. To understand concept of ANOVA, 2. To learn concept of Design of Experiments, 3. To learn applications of various designs of experiment. 					
Course Outcomes:					
<ol style="list-style-type: none"> 1. Learner will be able to apply ANOVA technique, 2. Learner will be able to identify situations where various designs can be used. 					
Detailed Syllabus: (per session plan)					
Unit	Description				Periods
1	<u>Analysis of Variance:</u> Introduction, Uses, Cochran's Theorem (Statement only). One way classification with equal & unequal observations per class, Two-way classification with one observation per cell. Mathematical Model, Assumptions, Expectation of various sums of squares, F- test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard Error and Confidence limits for elementary treatment contrasts.				15
2	<u>Design Of Experiments:</u> Concepts of Experiments, Experimental unit, Treatment, Yield, Block, Replicate, Experimental Error, Precision. Principles of Design of Experiments: Replication, Randomization & Local Control. Efficiency of design D1 with respect to design D2. Choice of size, shape of plots & blocks in agricultural & nonagricultural experiments.				15
	<u>Completely Randomized Design (CRD) & Randomized Block Design (RBD):</u> Mathematical Model, Assumptions, Expectation of various sums of				

	<p>squares, F-test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard error and Confidence limits for elementary treatment contrasts. Efficiency of RBD relative to a CRD. Missing plot technique for one missing observation in case of CRD, RBD.</p> <p><u>Introduction to Incomplete Block design:</u> Balanced Incomplete Block Design (BIBD). Concepts of Parameters of BIBD, Parametric relationships</p>	
3	<p><u>Latin Square Design (LSD):</u> Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard error and Confidence limits for elementary treatment contrasts. Efficiency of the design relative to RBD, CRD and LSD. Missing plot technique for one missing observation in case of LSD.</p> <p><u>Factorial Experiments:</u> Definition, Purpose & Advantages. 2^2, 2^3 Experiments. Calculation of Main & interaction Effects. Yates' method. Analysis of 2^2 & 2^3 factorial Experiments using RBD.</p>	15
	Total	45

Reference Books:

1. Experimental Designs: W.G. Cochran and G.M. Cox; Second Edition; John Wiley and Sons.
2. The Design and Analysis of Experiments: Oscar Kempthorne, John Wiley and Sons.
3. Design and Analysis of Experiments: Douglas C Montgomery; 6th Edition; John Wiley & Sons.
4. Design and Analysis of Experiments: M.N. Das and N.C. Giri, 2nd Edition; New Age International (P) Limited;1986.
5. Experimental Design, Theory and Application: Walter T Federer; Oxford & IBH Publishing Co. Pvt. Ltd.
6. Fundamentals of Applied Statistics: S.C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand and Sons (2001).
7. Statistical Principles in Experimental Design: B.J. Winer, McGraw Hill Book Company.
8. Theory and Methods of Survey Sampling: Parimal Mukhopadhyay, (1998), Prentice Hall Of India Pvt. Ltd.

List of Topics for the practicals:

Topic of the Practical	No. of Practicals
One Way Analysis of Variance	1
Two Way Analysis of Variances	1
Completely Randomized Design	1
Randomized Block Design	1
Latin Square Design	1
Missing Observations in CRD, RBD & LSD	1
Factorial Experiments	2
Use of R-Software in ANOVA & DOE	2

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for laboratory work and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

Programme: B. Sc.				Semester: IV	
Course: Statistics Paper III (OPERATIONS RESEARCH II)				Course Code: BH. USST403	
Teaching Scheme				Evaluation Scheme (Theory)	
Lecture (Periods per week)	Practical (Periods per week per batch)	Tutorial (Periods per week batch)	Credits (Theory + Practical)	Continuous Internal Assessment (CIA)	End Semester Examination (ESE)
3	3	--	2+1	(Marks: 40)	(Marks: 60)
Pre-requisites: NIL					
Course Objectives: 1.To learn techniques of Industrial Statistics like PERT and CPM. 2.To learn techniques of decision theory and game theory. 3. To present theory, mathematical computation and applications of network analysis, decision making and game theory. 4.To make students familiar with computation using R Software.					
Course Outcomes: 1.After completion of course students will be able to apply the techniques in practical situations. 2.Students will be able to use mathematical computation of network analysis, decision theory and game theory. 3.Students will be familiar with R software.					
Detailed Syllabus: (per session plan)					
Unit	Description				Periods
1	CPM and PERT: Objective and Outline of the techniques. Diagrammatic representation of activities in a project: Gantt Chart and Network Diagram. Slack time and Float times. Determination of Critical path. Probability consideration in project scheduling. Project cost analysis. Updating.				15

2	<p>GAME THEORY: Definitions of Two persons Zero Sum Game, Saddle Point, Value of the Game, Pure and Mixed strategy, Optimal solution of two-person zero sum games. Dominance property, Derivation of formulae for (2 x 2) game. Graphical solution of (2 x n) and (m x 2) games. Reduction of game theory to LPP and solution by Simplex Method.</p>	15
3	<p>DECISION THEORY: Decision making under uncertainty: Laplace criterion, Maximax (Minimin) criterion, Maximin (Minimax) criterion, Hurwitz criterion, Minimax Regret criterion. Decision making under risk: Expected Monetary Value criterion, Expected Opportunity Loss criterion, EPPI, EVPI. Bayesian Decision rule for Posterior analysis. Decision tree analysis along with Posterior probabilities.</p>	15
	Total	45

Reference Books:

1. PERT and CPM, Principles and Applications: Srinath. 2nd edition, East-West Press Pvt. Ltd.
2. Quantitative Techniques for Managerial Decisions: J.K. Sharma, (2001), MacMillan India Ltd.
3. Mathematical Models in Operations Research: J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.
4. Operations Research: S.D. Sharma. 11th edition, KedarNath Ram Nath & Company.
5. Operations Research: Kant Swaroop and Manmohan, Gupta. 12th Edition; S Chand & Sons.
6. Schaum Series book in O.R. Richard Bronson. 2nd edition Tata McGraw Hill Publishing Company Ltd.
7. Bronson R.: Theory and problems of Operations research, First edition, Schaum's Outline series
8. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons.
9. Operations Research: H. A. Taha., 6th edition, Prentice Hall of India.
10. Vora N. D.: Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
11. Bannerjee B.: Operation Research Techniques for Management, First edition, Business Books
12. S.G. Purohit, S.D. Gore, S.R. Deshmukh, Statistics using R Narosa Publishing
13. Maria.L. Rizzo (2007), Statistical Computing with R - (Chapman & Hall/CRC)

List of Topics for the practical:

Topic of the Practical	No. of Practical
CPM and PERT	3
Game Theory	2
Decision theory	2
Computation using R software in O.R.	3

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for laboratory work and journal (40+10 =50): Course code BH. USSTP04.

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

Overall Examination & Marks Distribution Pattern
Semester III & IV

Course	01			02			03			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	300
Practical	---	50	50	---	50	50	---	50	50	150

Rubrics of evaluation for ESE

Unit	Knowledge	Understanding	Analytical & critical thinking	Total marks/unit
1	05	05	05	15
2	05	05	05	15
3	05	05	05	15
All units	05	05	05	15
Total per objective	20	20	20	60
% weightage	33.33	33.33	33.34	100

Rubrics of evaluation for CIA-2 assignment: Presentation/debate

Class: _____ **Roll No** _____ **Topic** _____

Parameter s	Max Marks	80 – 100% Excellent	60 -80% Good	40 – 60% Satisfactory	20 – 40% Poor	0-20% very poor
Content	10					
Content: Introduction –	02					
Content: Development	03					
Content:– Conclusion -	03					
Content: - Bibliography	02					
Effective communicati on skill	10					
Language, Style and Structure;	05					
Teaching aids;	05					
Total	20					

Name of evaluator _____

date _____

EXAMINATION PATTERN

FOR ALL THEORY COURSES:

- 40 marks Continuous Internal Assessment (CIA) & 60 marks End Semester Examination (ESE) for a theory course and 100 marks semester end evaluation for a practical course.
- One CIA of 20 marks during a semester with objective type questions/MCQ test using online/offline mode, testing conceptual understanding /analytical and numerical abilities.
- One CIA of 20 marks involving assignments/survey presentation and analysis/ literature review/ book review/project.
- **In case of offline evaluation**, 60 marks and Two-hour duration ESE containing 4/5 compulsory questions of 15/12 marks each with internal options. One descriptive type of question on each unit and one objective type of questions based on all units in the syllabus.
- **In case of online evaluation**, 60 marks and 90 minutes duration ESE containing 3/4 sections (unit wise) each containing 20 marks/15marks MCQs of 1 or 2 marks on each unit in the syllabus. Questions to be framed in such a manner that it would test students' understanding, analytical abilities, and critical thinking.

FOR ALL PRACTICAL COURSES:

- 40 marks and 2 hours evaluation per course based on practicals conducted during the semester which will test ability to apply the statistical tools and techniques in practical situations, numerical and analytical abilities of students. Problem solving using statistical packages to be tested wherever feasible. 10 marks per course be allocated to viva/journal /computer laboratory work.

1	Rational on which revision is done.
	Stated above
2	Rational for M.Sc. Syllabi.
	-NA-
3	What is the new idea you want the student to Learn.?
	To give basic idea of a concept in accordance with the topic that is taught in TYBSc. R-software is introduced to the students to gain the knowledge of practical application of theory topics that are learnt in the course.
4	Which foreign and national syllabi have you checked and what did you include from it ?
	We checked syllabi of Harvard University, Pune University, Jalgaon University, Delhi University. Not included any topic from it as our syllabi contains some of the topics from these syllabi.
5	The change in syllabi that will create new Jobs
	Consulting companies like TCS, EY, Accenture etc. uses Software like R which will be beneficial for the students to look for jobs. Data science is completely based on core statistics. Companies like Flipkart, Amazon, Myntra etc. use recommendation systems which are operated on Software like R.
6	Self-study material
	Students can opt for different course on Swayam, Coursera, NPTEL, Udemy etc. Students can refer to websites like NDL, KDnuggets academia etc. for various reference books, research papers and for reading & writing blogs.